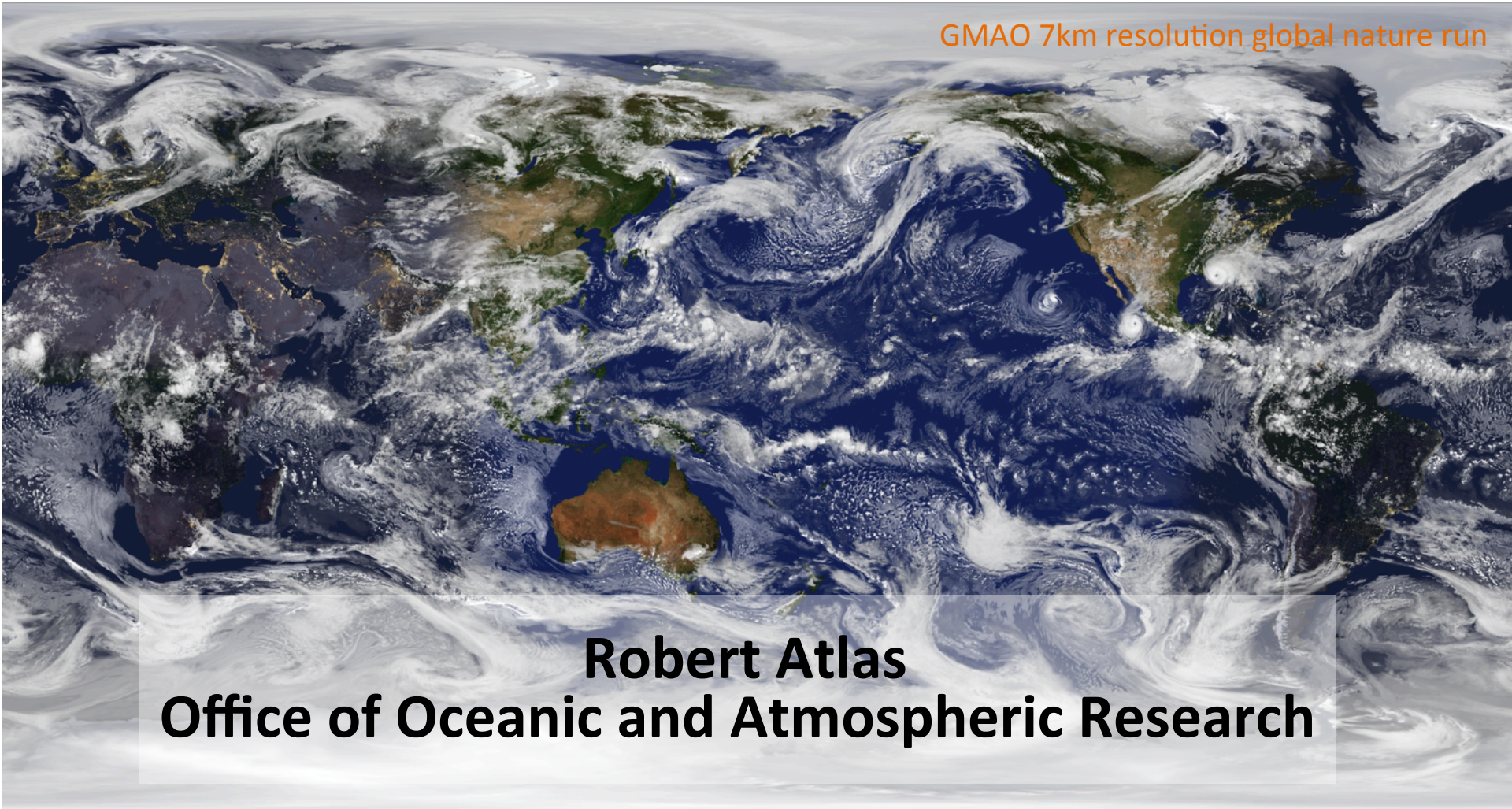
Quantitative Observing System Assessment Program (QOSAP)

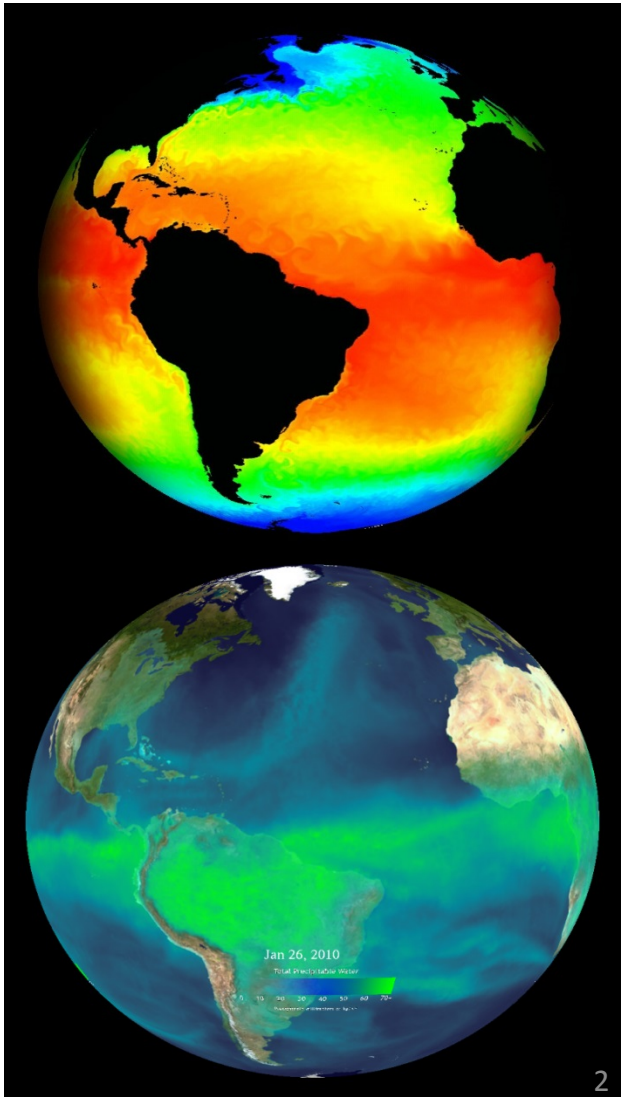


Robert Atlas
Office of Oceanic and Atmospheric Research

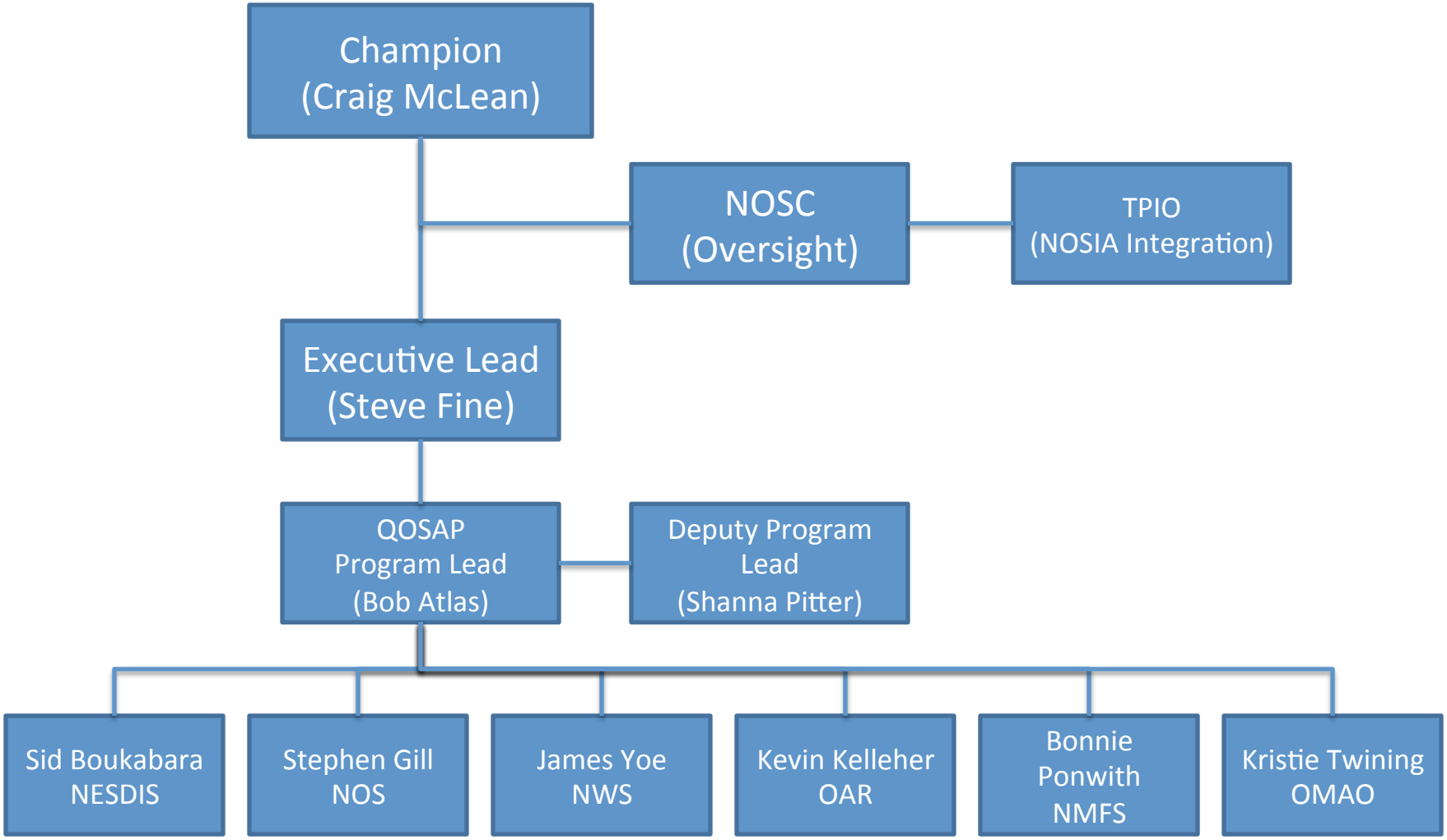
QOSAP's Primary Objectives

Improve quantitative and objective assessment capabilities to evaluate operational and future observation system impacts and trade-offs to assess and to prioritize NOAA's observing system architecture.

- Increase NOAA's capacity to conduct quantitative observing system assessments.
- Develop and use appropriate quantitative assessment methodologies.
- Inform major decisions on the design and implementation of optimal composite observing systems.



QOSAP's Multi - LO Governance



QOSAP's Annual Milestones

Milestones/Deliverables to NOSC	Planned Completion Date
Annual plan: quantitative assessment project prioritization and selection	**Q2**
Performance reports on projects	Q4
Inventory of Results of Quantitative Assessments	Q4
Collection of Driving Research Questions for a QOSAP needs assessment	Q4
End of Fiscal Year Progress Report to NOSC	Q1 of next FY

- In May 2014, OMB was provided with an INVENTORY of OSSE/OSE assessments conducted within NOAA over the previous 5 years.
- 55 assessments were reported with their main results and applicable publication(s) at that time, then an additional assessment was added in a subsequent update.

Assessment Prioritization Schema

- **For each proposed assessment topic/question we answered:**

  Question 1: Is there a pressing need for the assessment to be executed in the current FY? [Yes/No]

  Question 2: Does NOAA currently have the capabilities in place to execute the assessment? [Yes/No]

  Question 3: Are there existing resources available for the assessment? [Yes/No] Estimate the amount needed/or additional above existing $ [$k]

  Question 4: Can the assessment be completed in the next 1-2 years? [Yes/No]

  Question 5: What is the potential value to NOAA and partners? [High, Medium, Low]

Prioritized Tiers for each FY

Priority Tier 1: Has Pressing need for immediate execution

- 1A: All factors align; need, $, capability, FY finish, high value
- 1B: All but 1 factor align; Need, capability, $, FY finish, yet lower value
- 1C: Need and high value, yet no capability or $
- 1D: Need, yet medium value and no capability or $ available.

Tier 1 will be started in current FY*

*If the capability cannot be developed in current FY, it will be deferred

Priority Tier 2: No pressing need for immediate execution yet capability exists (may need $)

- 2A: At least 2 other factors align
- 2B: 1 factor aligns and medium+ value
- 2C: 1 factor aligns

Tier 2 may be started in next FY

Priority Tier 3: No pressing need, capability, nor resources

- 3A: High value
- 3B: Medium-Low value

Tier 3A will be further defined in current or next FY; Assessment in later FY

CURRENT STATUS AND SELECT RESULTS

Current Status of OSSEs

- OSSEs have been performed using an older global OSSE system based on an ECMWF T511 nature run and the regional Hurricane OSSE system developed at AOML.

- A new state of the art global OSSE system based on the NASA Cubed Sphere at 7 km resolution NR has been developed and is being calibrated at this time. This will replace the current global OSSE system at OAR/ESRL and JCSDA.

- New and expanding regional OSSE systems for high impact weather have been and are being developed.

- A state of the art ocean OSSE System has been developed and is expanding.

Sample Assessment Results

- OSSE on the impact of **Enhanced GPS Radio Occultation** (COSMIC-2 equatorial and polar; commercial options). **$;** Responsibility: **ESRL/GSD, JCSDA, AOML**

  - **Status: Preliminary OSSEs have been completed, working with a more realistic OSSE system soon. Completion expected in FY 16.**

  - **The preliminary results show that increasing the number of assimilated RO satellites results in better weather forecast skill:**
    - **18 sat is better than 12 sat;**
    - **12 sat is better than 6 sat.**

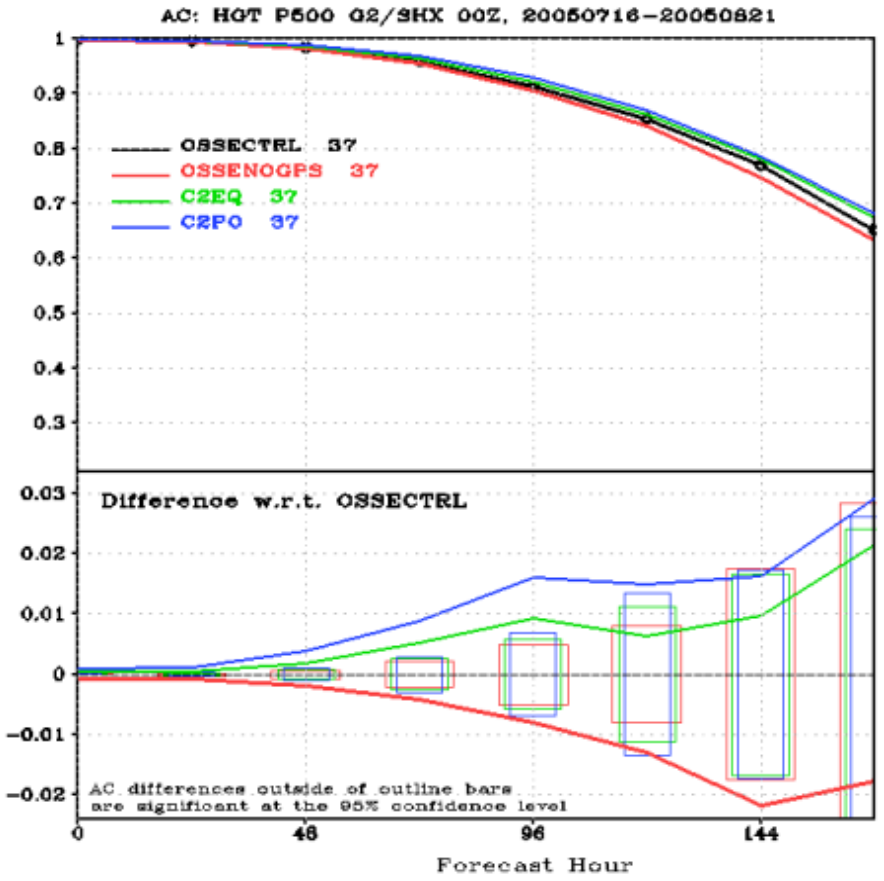
$= Fully Funded existing LO project (incl Sandy Supplemental)

Results of the GPSRO Occultation OSSE

Experiments (preliminary OSSEs)

- **OSSECTRL (6 satellites)**: control, all observations
- **OSSENOGPS**: control without RO observations
- **C2EQ (12 satellites)**: control + COSMIC-2 equatorial
- **C2PO (18 satellites)**: control + COSMIC-2 equatorial + COSMIC-2 polar

500-mb geopotential height anomaly correlation
Southern Hemisphere

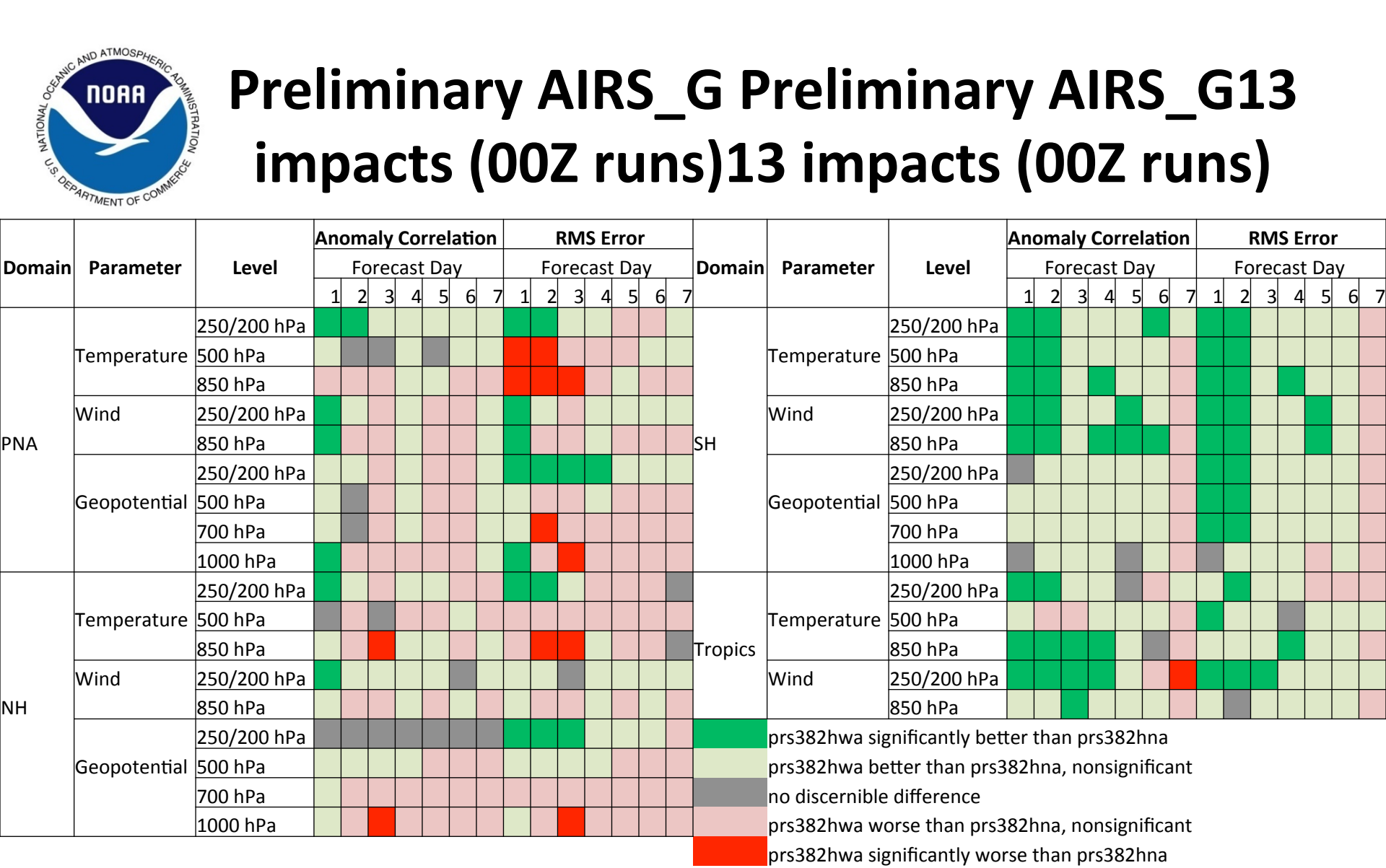


Sample Assessment Results

- OSSE on the impact of **Geostationary Hyperspectral sensors** (including commercial alternatives and GOES-R ABI). **$$**; Responsibility: **AOML, NESDIS, JCSDA, NSSL**
  - **Status: Preliminary OSSEs have been completed, working with a more realistic OSSE system soon. Completion expected in FY 16.**
  - **The global model experiments showed a significant improvement in forecast accuracy in the southern Hemisphere, but not over North America.**
  - **The results of hurricane model experiments are mixed, but indicate modest potential to improve hurricane forecasts. Both temperature and moisture data are important.**

$**= Fully Funded existing LO project (incl Sandy Supplemental), **$= QOSAP provides additional/all funding

Preliminary AIRS_G Preliminary AIRS_G13 impacts (00Z runs)13 impacts (00Z runs)



- **Bright Green, Red = statistically significant**
- Visual interpretation, erred on side of caution (i.e., calling results "significant" only if clear without a doubt)

Sample Assessment Results

- OSSE to determine the potential impact of **CYGNSS surface wind** observations on hurricane analyses and forecasts.$; Responsibility: **AOML**

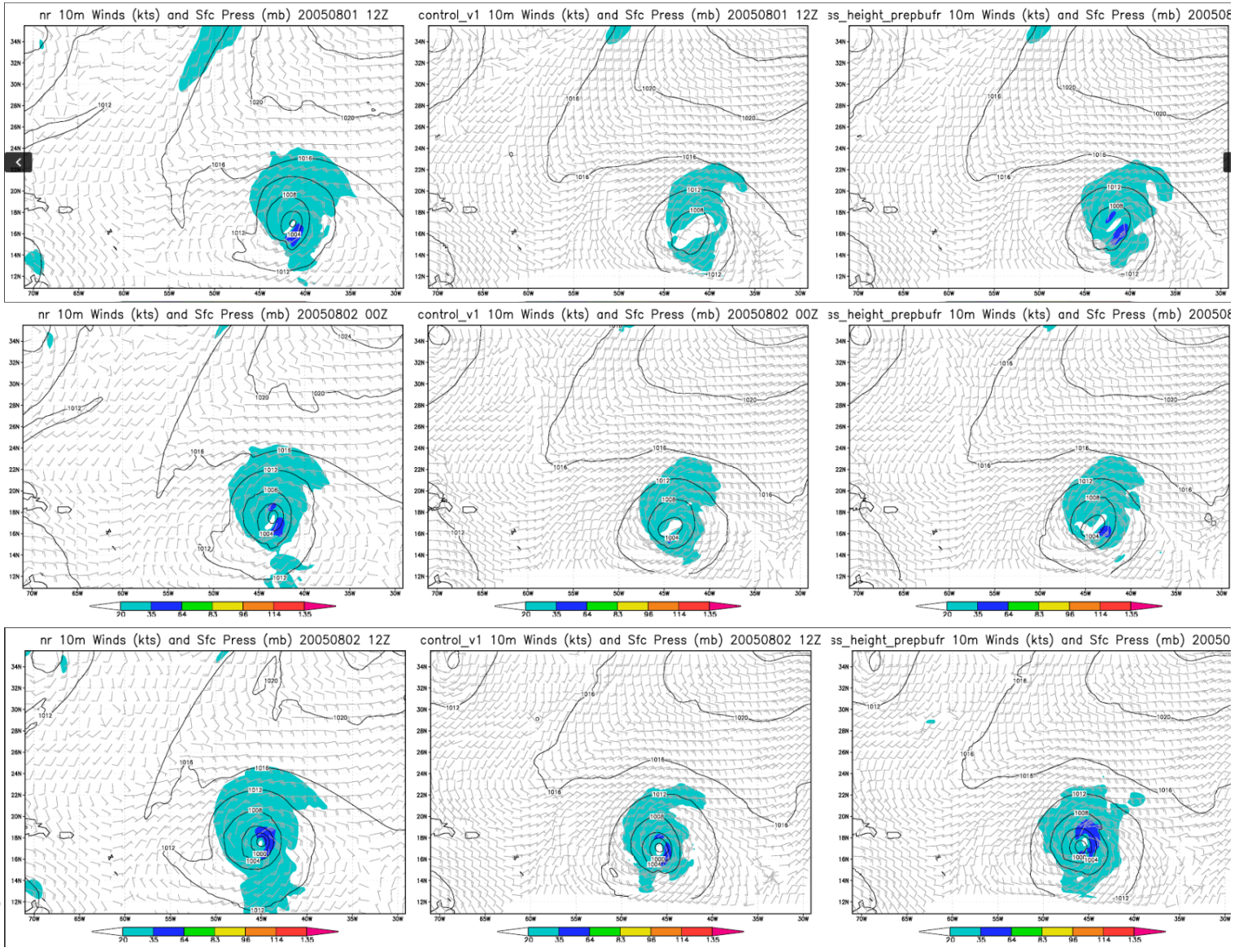
  - **Status: Completed.**

    - **AOML completed an initial study using the HWRF model with GSI, that showed potential to improve hurricane analyses and short-range forecasts, provided the CYGNSS mission meets it's performance requirements.**

$= QOSAP provides additional/all funding

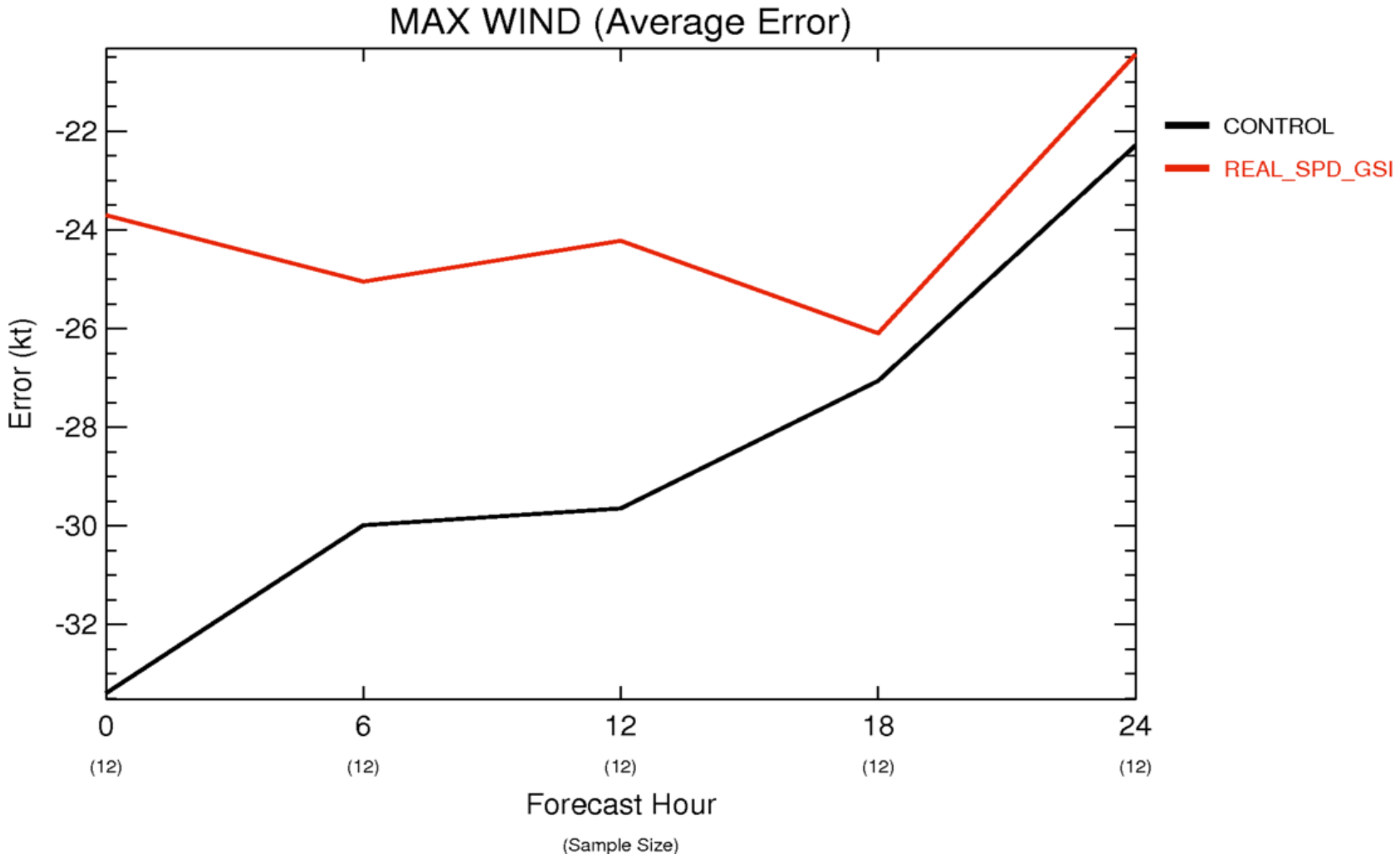
Impact of CYGNSS on Surface analyses using HWRF GSI

NATURE CONTROL CYGNSS



Impact of CYGNSS Data

(with realistic errors on HWRF 24 h Max Wind Forecasts)



Sample Assessment Results

Ocean OSSE System

- Developed by the joint AOML/CIMAS/RSMAS Ocean Modeling and OSSE Center (OMOC)
  - Incorporates all design criteria and rigorous validation methods developed for atmospheric OSSE systems

- Initial Gulf of Mexico implementation

  The system was validated by comparing OSEs to OSSEs for the following experiments:

  - Assimilate all observations
  - Deny airborne ocean profiles collected during the Deepwater Horizon oil spill
  - Further deny two of three altimeters
  - Further deny the third altimeter
  - Deny all observations

- System validation results for the Gulf published in *JTECH*, Jan. 2014; OSSE results published in 2015.

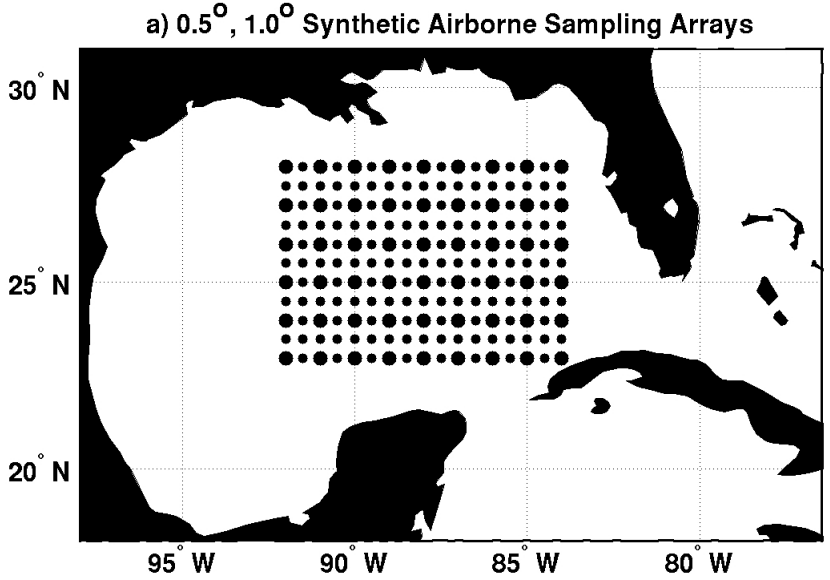
Results of the Ocean OSSE (1)

1. Impact of denying airborne profiles
   - Analysis RMS errors of Sea Surface Height (SSH) and Tropical Cyclone Heat Potential (TCHP) increased by ~50%
   - TCHP bias of near zero increased to ~10 kJ cm^{-2}
   - Forecast RMS error increased, initially by 50% and then by 20-30% between forecast days 5 and 60.
2. Horizontal profile resolution
   - Analysis RMS errors increased by 20-30% for SSH and 30-40% for TCHP when resolution decreased from 0.5 degree to 1.0 degree
   - TCHP bias of ~1 kJ cm-2 increased to 3-4 kJ cm-2
   - Profile surveys are effective at controlling the smaller-scale structure of ocean features that is poorly constrained by altimetry

Results of the Ocean OSSE (2)

3. Profiler type and depth range (400 m AXBT versus 1000 m AXCTD)
   - Analysis RMS errors increased 10-20% for SSH; no impact on TCHP
   - AXCTDs, which also measures salinity and samples a larger depth range compared to AXBTs, are more effective at constraining the structure of upper-ocean dynamical fields
4. Temporal resolution of surveys
   - Experiments performed for temporal resolutions of 1, 2, 4, 8, and 16 days
   - RMS error reduction for SSH was 10% for 16 days and nearly 50% for daily surveys
   - RMS error reduction for TCHP was 10% for 16 days and nearly 40% for daily surveys
   - Airborne surveys need to be conducted at least twice weekly to approach maximum error reduction

Impact of Horizontal Profile Resolution on SSH (RMS error)



The idealized airborne survey patterns on the 0.5º grid (all points) and the 1.0º grid (large points only) is shown at left.

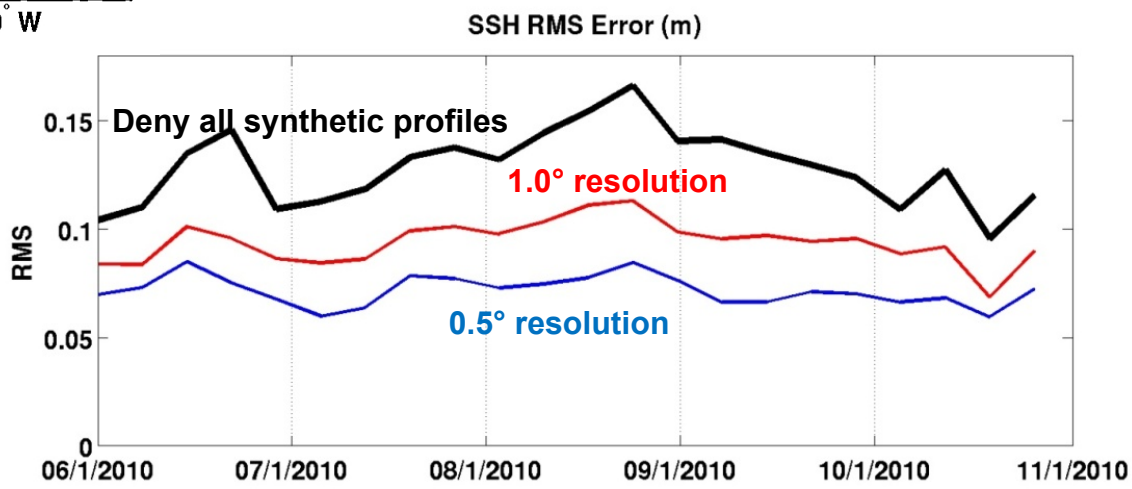
Large area chosen to obtain robust statistics.

Ocean dynamical fields represented by SSH

Impact assessments recently accepted by *Progress in Oceanography*

Decreasing horizontal resolution has a large impact on RMS errors of SSH

Higher-resolution profiling constrains smaller-scale horizontal structure (fronts and small-scale eddies) that is not well constrained by satellite altimetry.



Summary

- QOSAP provides ***quantitative*** impacts of observations on products while NOSIA-2 has ***qualitative*** impacts on products and services. NOSIA should incorporate QOSAP results into that analysis.

- Successes due to leveraged work across LOs.

AIRS Data Impacts on Regional TC Analyses and Forecasts

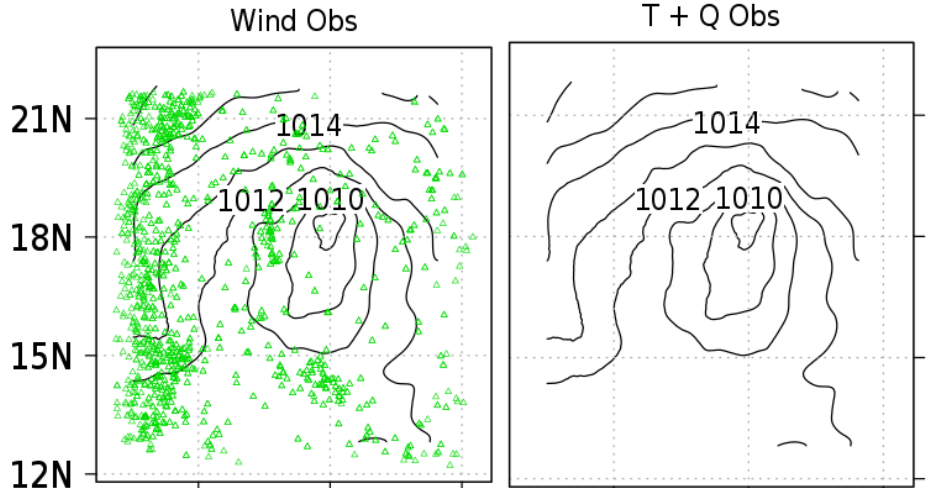
Experiment Design

	EXP A	EXP B	EXP C	EXP D
EXP SET 1	AMV	AMV + G-IV/GH Thermo	AMV + AIRS Thermo	AMV + GH & AIRS Thermo
EXP SET 2	AMV + ***G-IV/GH Winds***	EXP 2A + G-IV/GH Thermo	EXP 2A + AIRS Thermo	EXP 2A + GH & AIRS Thermo
EXP SET 3	AMV + ***G-IV/GH Winds + P3 & AF Obs***	EXP 3A + G-IV/GH Thermo	EXP 3A + AIRS Thermo	EXP 3A + GH & AIRS Thermo

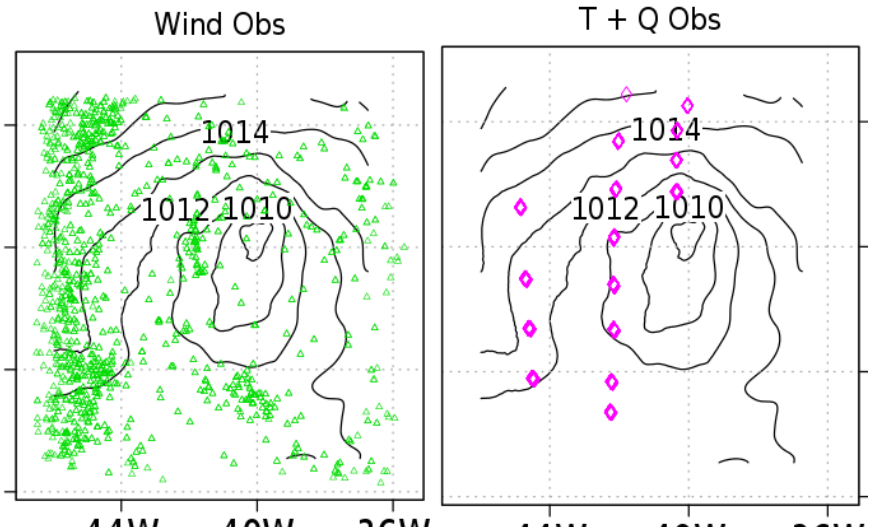
G-IV Winds includes: Drop + Flt-level + SFMR + TDR
G-IV Thermo includes T and q observations from Drop + Flt-level
GH Winds/Thermo includes: Dropsonde
P3 & AF Obs includes both the winds and thermo observations from Drop + Flt-level + SFMR + TDR

Assimilated Data Distribution: EXP SET1

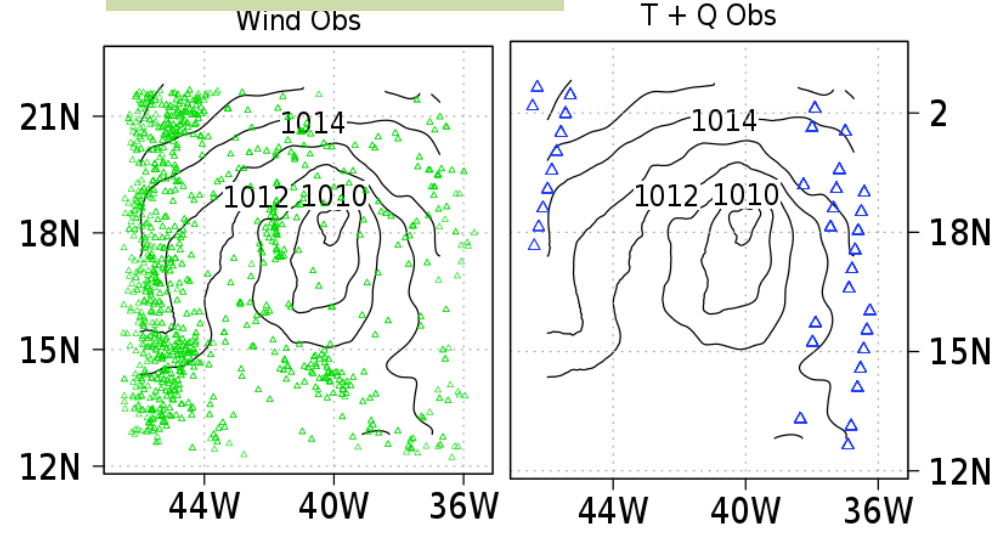
EXP1: AMV



EXP1 + GH T&q



AMV + AIRS T&q

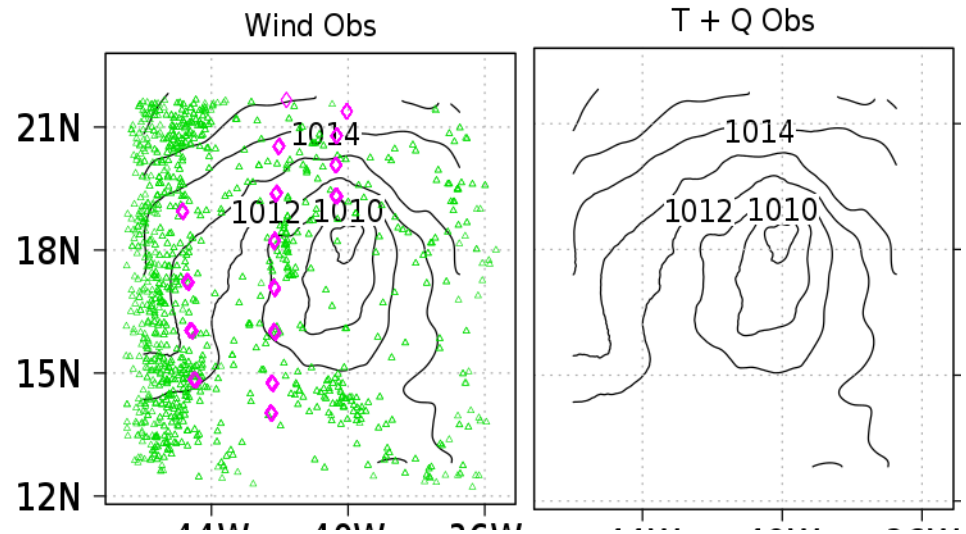


Edouard(2014)
06Z 12 September

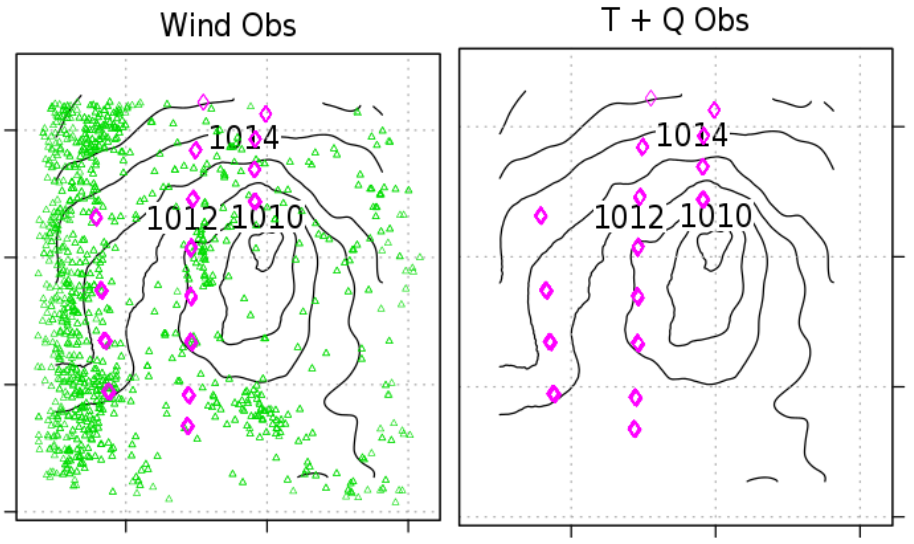
NHC best track at this time:
10-m Wind Speed: 35knots
SLP: 1005hPa

Assimilated Data Distribution: EXP SET2

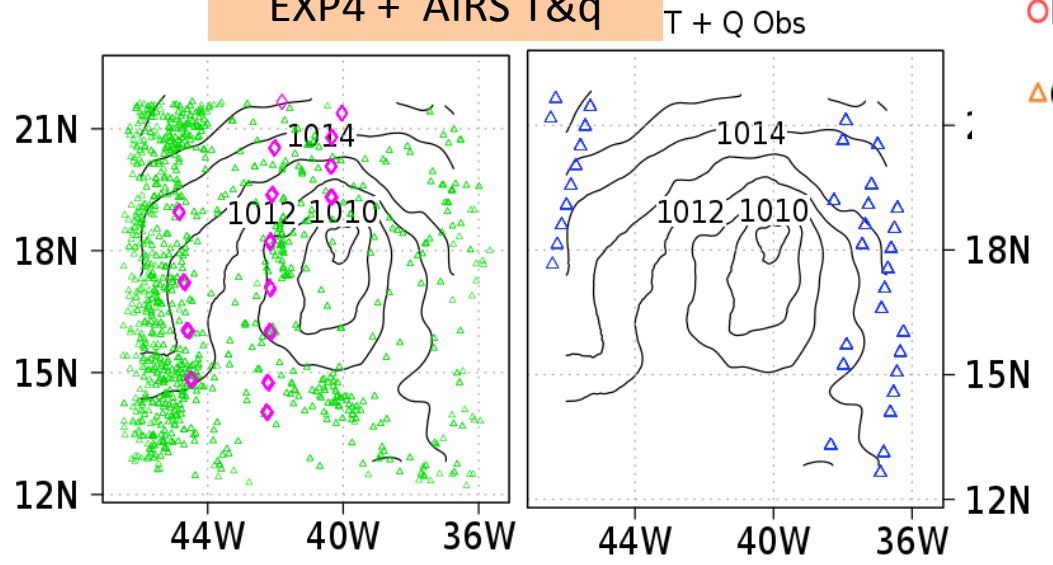
EXP4: AMV + GH Drop Winds



EXP4 + GH T&q



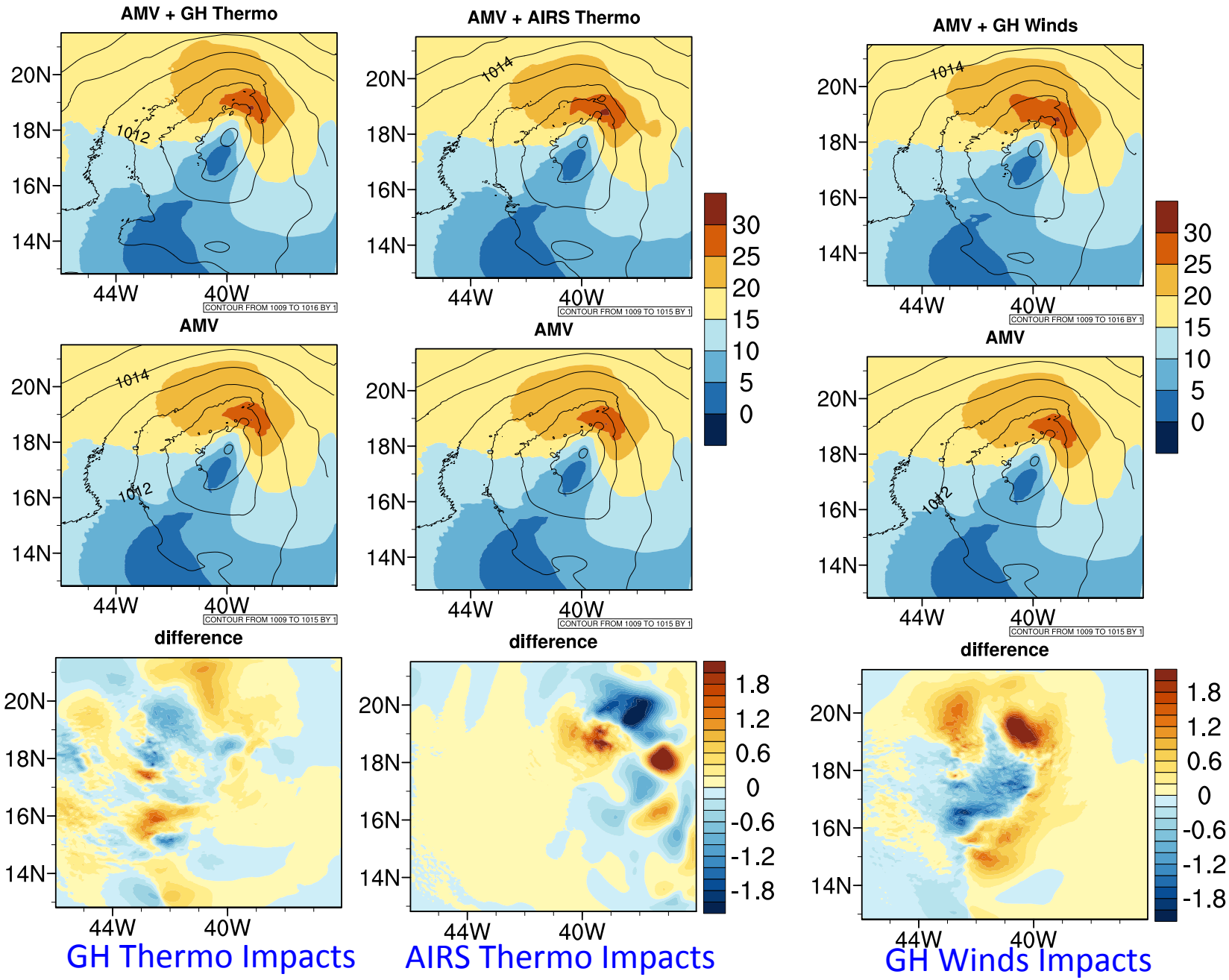
EXP4 + AIRS T&q



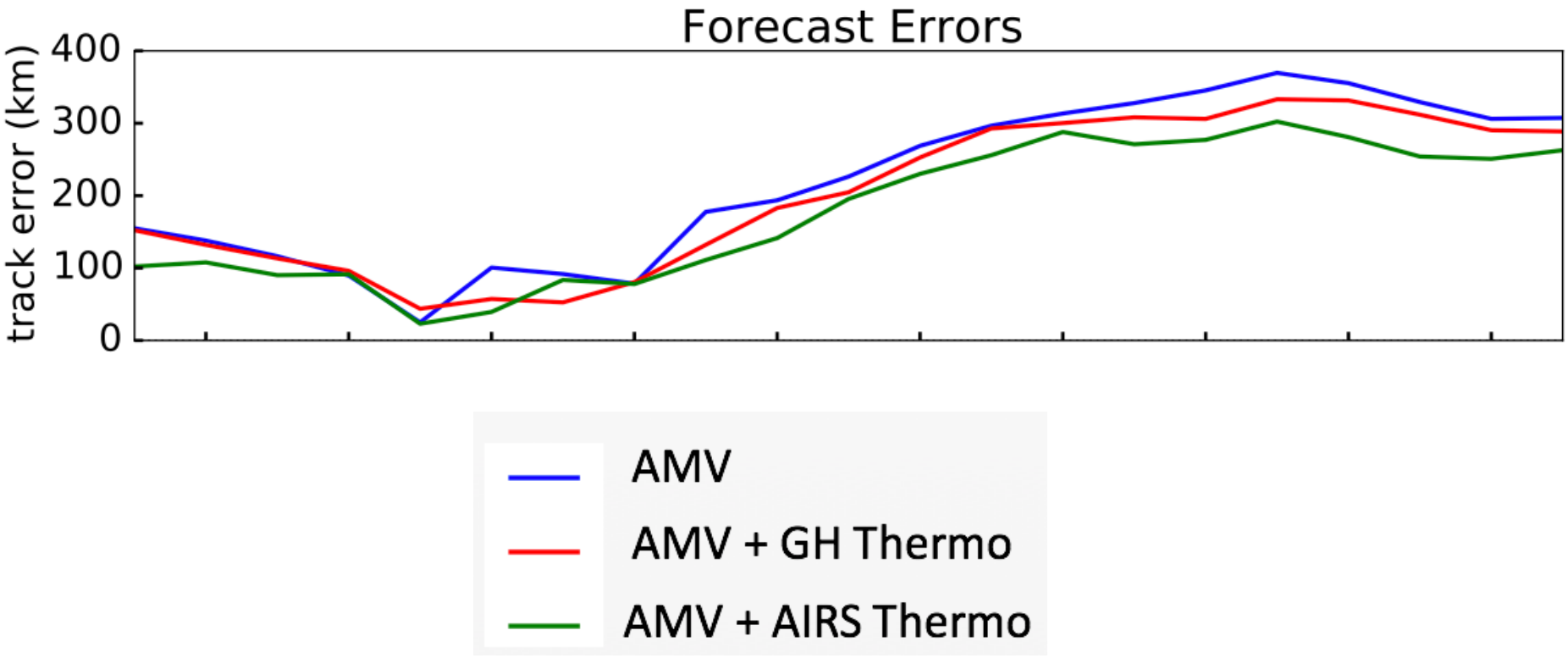
P3 GH Flt-Level SFMR TDR AMV GPS AIRS

Compared to previous experiment set, adding GH Winds obs in the control experiment

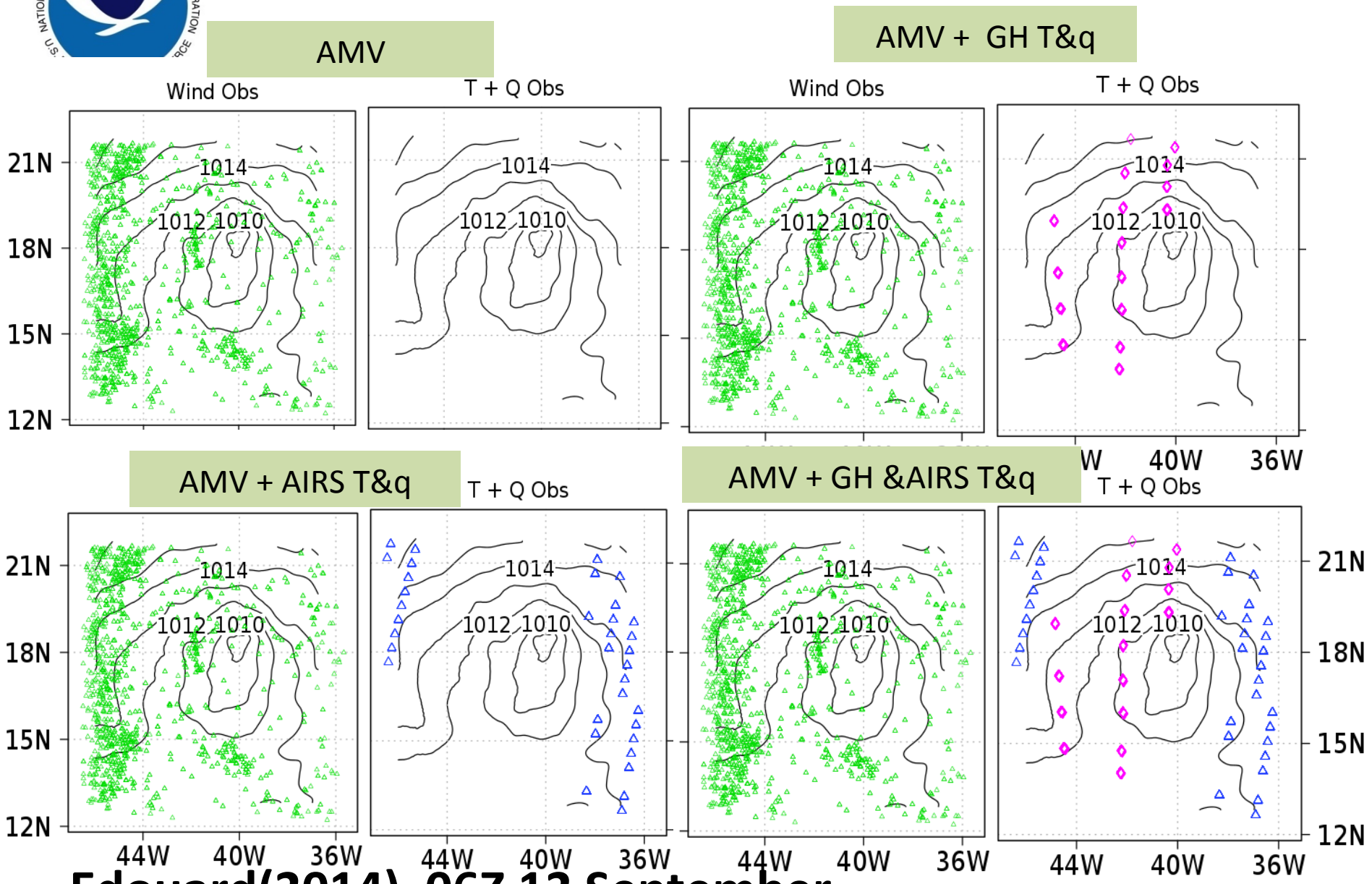
10-m Wind Speed Analysis



Impacts on TC Forecasts: EXP SET1

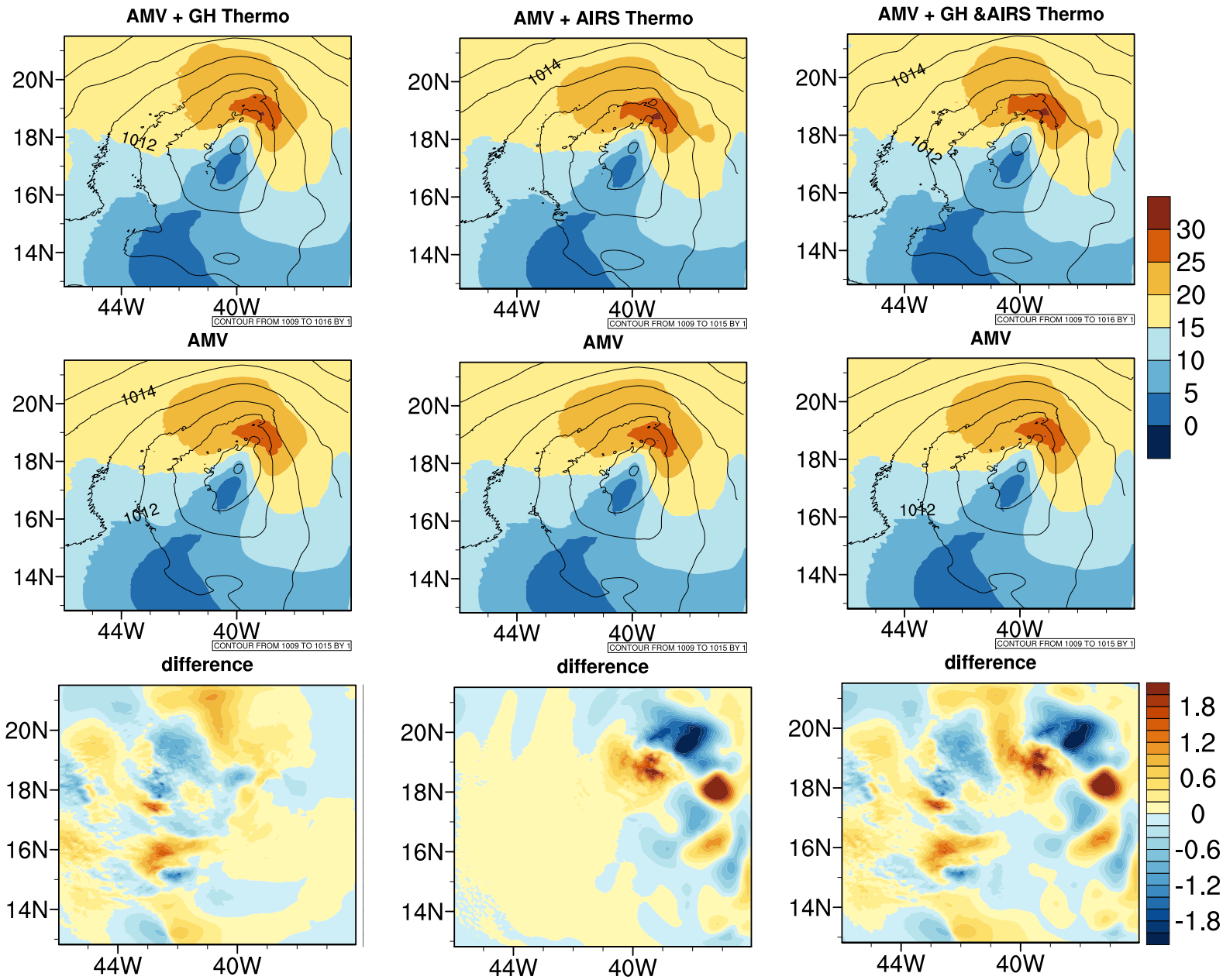


Assimilated Data Distribution: EXP SET1

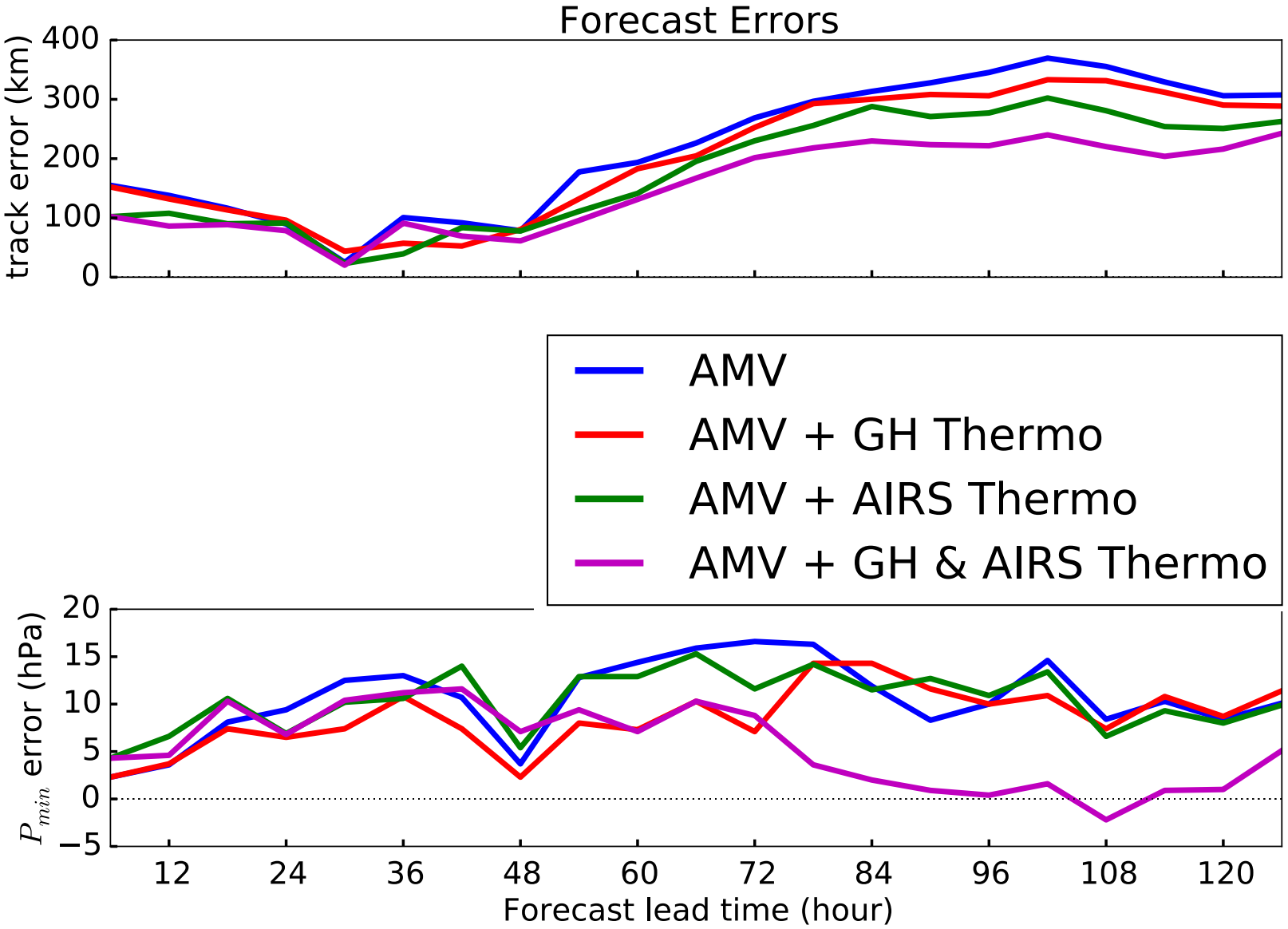


Edouard(2014) 06Z 12 September

10-m Wind Speed Analysis



Impacts on TC Forecasts: EXP SET1



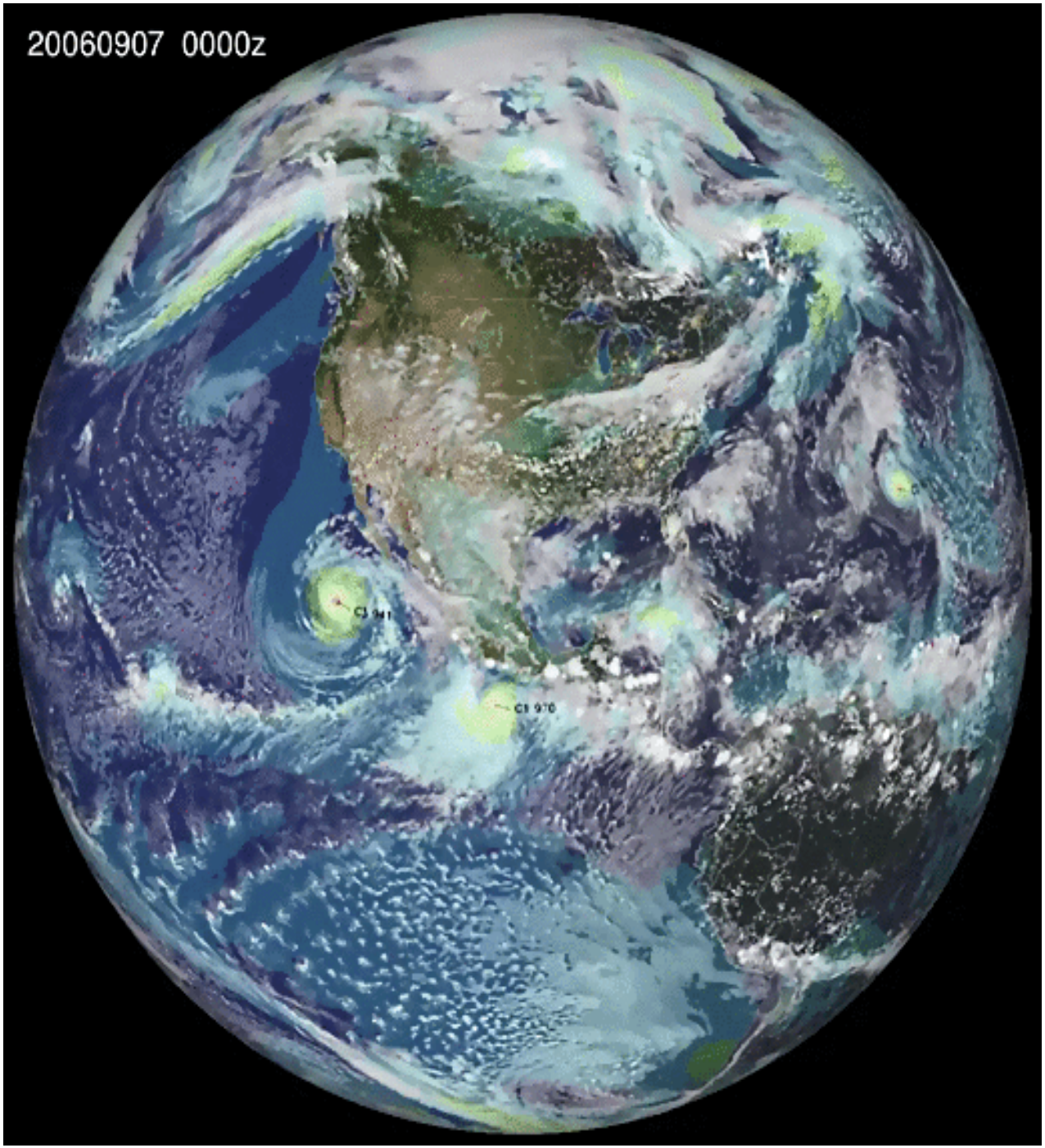
Preliminary Conclusions

- For the Hurricane Edouard case study on September 12 06Z, AIRS retrievals show an consistent positive impact on the track forecasts in experiment sets 1 and 2.

- Assimilation of AIRS and GH temperature and moisture data results in a larger impact than either one individually on both track and intensity forecasts in this case.

- This suggests that targeting with UAS or recon aircraft should be designed to complement the coverage of available satellite data.

- Many more cases need to be examined.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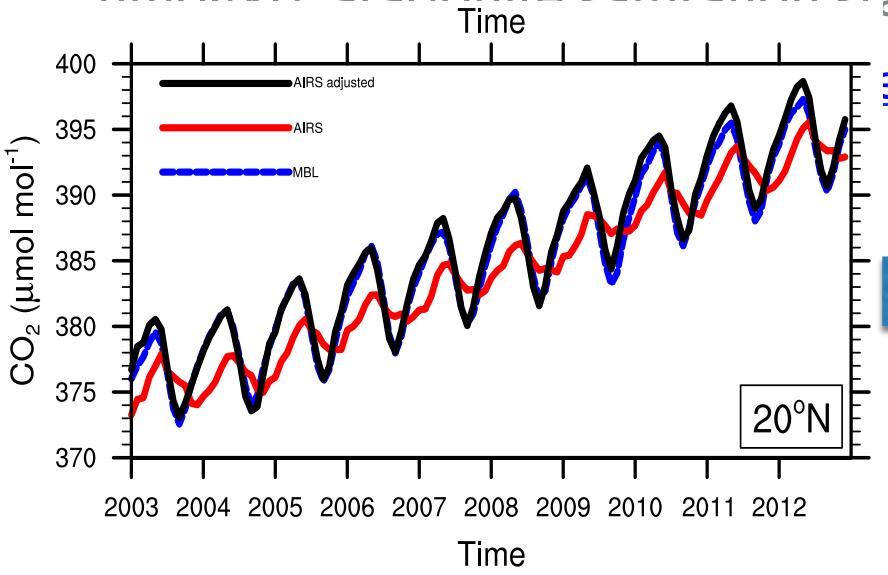
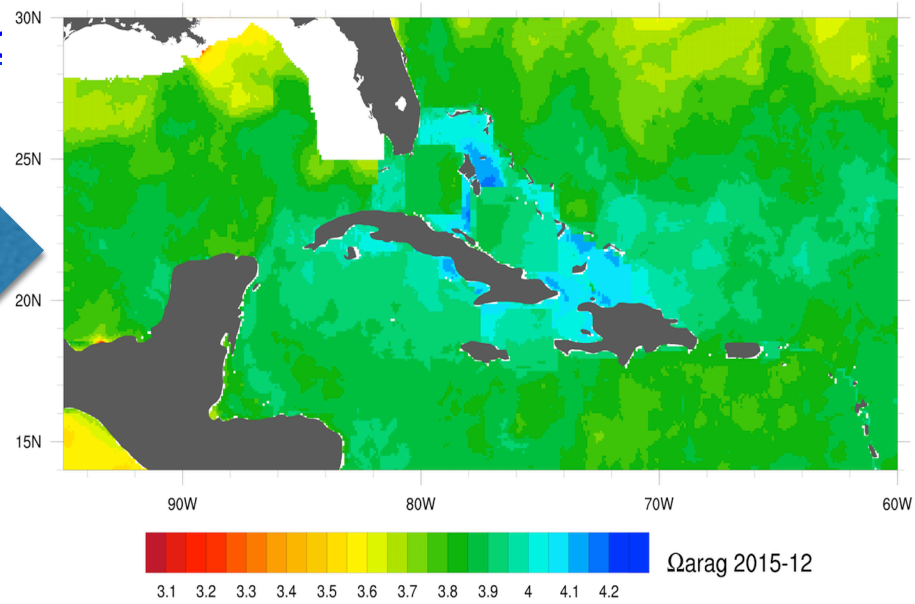
AIRS APPLICATION: OCEAN ACIDIFICATION PRODUCT SUITE

- An unique application: mid-tropospheric soundings from AIRS are used to approximate pCO_2 of surface waters.
- AIRS [CO_2] is adjusted by replacing the annual cycle at each location with that of the GLOBALVIEW-CO_2 reference marine boundary layer.
- Ocean Acidification (OA) variables that can be downloaded in netCDF and images: pH, surface pressure of CO_2, total alkalinity in umol/kg, aragonite saturation state and calcite saturation state

AIRS is the dynamic driver for changes in the OA model

Saturation state in the coral reef regions of the Caribbean





Red: AIRS Mid troposphere CO_2
Blue: Marine Boundary Layer CO_2 (from NOAA/CMDL/GMD)
Black: Adjusted AIRS to MBL values

Blue: High Aragonite saturation state (good for corals)
Red: Low Aragonite saturation state (not so good for corals)